ↄ D F

PATENT SPECIFICATION

(11) 1 424 162

1 424 162

(21) Application No. 2491/74 (22) Filed 18 Jan. 1974

(44) Complete Specification published 11 Feb. 1976

(51) INT CL² C04B 31/30

(52) Index at acceptance

C1H 120 620 714 715 717 724 727 730 732 738 739 744

C3N 12

(19)

(72) Inventors AVGUST VYACHESLAVOVICH ANDREICHENKO, JURY NIKOLAEVICH VERSHININ, LEV EVGENIEVICH VRUBLEVSKY, VALERY PAVLOVICH GORELOV, MIKHAIL STANISLAVOVICH OBZHINSKY, LEONID SOLOMONOVICH DAVYDOZ, ALEXEI ANDREEVICH ZHAVORONKOV, VALENTIN DMITRIEVICH ZORIN, RUSLAN VLADIMIROVICH MANCHUK, IRINA VLADIMIROVNA NIKOLAEVA and GALINA MIKHAILOVNA LOGACHEVA

(54) ELECTROCONDUCTIVE MATERIAL

(71) We, SIBIRSKY NAUCHNO-ISSLEDOVATELSKY INSTITUT ENERGETIKI of ulitsa Frunze, 9, Novosibirsk, Union of Soviet Socialist Republics, a State Enterprise organised and existing under the laws of the Union of Soviet Socialist Republics, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to electroconductive materials adapted for use in electrical engineering and more specifically, to materials with a predetermined resistivity value.

The present invention may be most efficiently used in the manufacture of volume resistors for high-voltage devices and electric circuits as well as in the production of structural elements for house-building and industrial construction.

Known in the art are electroconductive nonbinder, necessitates a high-temperature (up to 1,700°C) calcination, for the production of such materials, effected mainly in a neutral or vacuum medium under strict compliance with the thermal conditions.

Maintenance of such temperature conditions combined with the use of a neutral or vacuum medium is rather costly and technologically involved.

Dimensions of articles made of such materials are limited due to internal strains originating during calcination and cooling. These articles have a thickness generally not exceeding 2 to 3 cm. Any non-uniformity in the structure of the article material causes, during the calcination process, an acute non-uniformity of the article properties thus exerting a detrimental effect on the final performance of the article.

It is an object of the present invention to provide an electroconductive material with a predetermined resistivity value which would possess combined properties of both resistive

PATENTS ACT 1949

SPECIFICATION NO 1424162

The following amendments were allowed under Section 29 on 29 November 1976

Page 13, line 13, *after* carbon *insert* with a processing temperature in the range 1200°C to 1700°C

THE PATENT OFFICE

PATENT SPECIFICATION

(11) 1 424 162

(21) Application No. 2491/74 (22) Filed 18 Jan. 1974

(44) Complete Specification published 11 Feb. 1976

(51) INT CL² C04B 31/30

(52) Index at acceptance
C1H 120 620 714 715 717 724 727 730 732 738 739 744
C3N 12

1 424 162

(19)

(72) Inventors AVGUST VYACHESLAVOVICH ANDREICHENKO, JURY NIKOLAEVICH VERSHININ, LEV EVGENIEVICH VRUBLEVSKY, VALERY PAVLOVICH GORELOV, MIKHAIL STANISLAVOVICH OBZHINSKY, LEONID SOLOMONOVICH DAVYDOZ, ALEXEI ANDREEVICH ZHAVORONKOV, VALENTIN DMITRIEVICH ZORIN, RUSLAN VLADIMIROVICH MANCHUK, IRINA VLADIMIROVNA NIKOLAEVA and GALINA MIKHAILOVNA LOGACHEVA

(54) ELECTROCONDUCTIVE MATERIAL

(71) We, SIBIRSKY NAUCHNO-ISSLEDOVATELSKY INSTITUT ENERGETIKI of ulitsa Frunze, 9, Novosibirsk, Union of Soviet Socialist Republics, a State Enterprise organised and existing under the laws of the Union of Soviet Socialist Republics, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to electroconductive materials adapted for use in electrical engineering and more specifically, to materials with a predetermined resistivity value.

The present invention may be most efficiently used in the manufacture of volume resistors for high-voltage devices and electric circuits as well as in the production of structural elements for house-building and industrial construction.

Known in the art are electroconductive nonmetallic materials with a predetermined resistivity value which materials comprise compositions incorporating dispersed carbon, a dielectric filler and a binder. As the binder for such materials, use is generally made of ceramics.

Electrical conductivity of the materials is ensured by introducing dispersed conductive or semi-conductive, predominantly carbonaceous, substances into the composition. The required resistivity value thereof is achieved by selecting the appropriate type of a dispersed conductor, varying its volumetric concentration and particle size, introducing special additives, and performing specific technological operations during the production of the materials and making articles therefrom.

It is known that the use of ceramics, as a binder, necessitates a high-temperature (up to 1,700°C) calcination, for the production of such materials, effected mainly in a neutral or vacuum medium under strict compliance with the thermal conditions.

Maintenance of such temperature conditions combined with the use of a neutral or vacuum medium is rather costly and technologically involved.

Dimensions of articles made of such materials are limited due to internal strains originating during calcination and cooling. These articles have a thickness generally not exceeding 2 to 3 cm. Any non-uniformity in the structure of the article material causes, during the calcination process, an acute non-uniformity of the article properties thus exerting a detrimental effect on the final performance of the article.

It is an object of the present invention to provide an electroconductive material with a predetermined resistivity value which would possess combined properties of both resistive composite materials and construction structural materials with no technological limitations as to dimensions of the articles being manufactured therefrom.

It is another object of the present invention to provide a material from easily available starting components which material would be simple to produce and less expensive compared to the prior art materials.

According to the present invention there is provided an electroconductive material with a predetermined resistivity value comprising a composition of a dielectric filler and a silicate binder with a dispersed carbon having particles of various sizes not exceeding 3 μ, uniformly distributed among the particles of said dielectric filler and silicate binder, said components being taken in the following pro-

portions: dispersed carbon from 6.75 to 85% by volume, dielectric filler from 1 to 60% by volume, and silicate binder from 7 to 85% by volume.

The use of dispersed carbon with particle size not exceeding 3 μ makes it possible, during the preparation of the composition, to obtain a material featuring more uniform properties, and more particularly, electrical conductivity; to provide an electroconductive system consisting dispersed carbon which possess enhanced heat-resistance and ensures reliability and a long service life of the articles made therefrom.

The possibility of varying the proportion of finely divided carbon particles of different sizes make it possible change the material resistivity, thermal resistance coefficient and non-linearity of current-voltage characteristics.

The use of finely-divided carbon with particles of different sizes, not exceeding 3 μ, and a silicate binder as well as variation of the volumetric concentration of dispersed carbou from 6.75 to 85% by volume at a corresponding variation of the volumetric concentration of a dielectric filler from 1 to 60% by volume and of a silicate binder from 7 to 85% by volume makes it possible to obtain a material with the value of resistivity ranging from 10^{-1} to 10^{5} ohm.cm.

One embodiment of tthe material according to the present invention comprises a composition, wherein as a silicate binder use is made of cement.

The use of cement as a silicate binder makes it possible to avoid the use of high-temperature conditions and neutral or vacuum media for the treatment of the material.

The use of cement as a binder enables the production of materials from readily available components which are simple to produce and less expensive as compared to those of the prior art, and to make articles of any dimensions from the material of the present invention, including structural elements for houses and buildings.

The electroconductive material according to the present invention containing cement as a silicate binder may be used for the manufacture of resistors, earthing connections, electroconductive floors, electric heaters, and electrostatic plaster shields.

Another embodiment of the material of the present invention contemplates the use, as a silicate binder, of a mixture of sodium liquid glass of a specific gravity of 1.32 g/cm^3 and sodium fluorosilicate in amountts ranging from 9 to 40% by volume based on the total volume of the composition.

The use of such a binder in amounts ranging from 9 to 40% by volume of the composition makes it possible to obtain a material which remains heat-resistant at temperatures of up to 500°C.

The material incorporating such a silicate binder may be used for the manufacture of resistors and heaters.

It is also possible to use, as a silicate binder for the material f the present invention, a mixture of cement and sodium liquid glass, the latter being employed in amounts of up to 30% of the total volume of the binder.

The use, as a silicate binder, of a mixture of cement with liquid sodium glass enables the heat-resistance of the material and the density thereof to be increased while retaining simple technology of making the material and articles therefrom which is characteristic of a cement binder. This ensures a more uniform temperature distribution throughout the material and articles made therefrom as electric energy is dissipated whereby the service life of the articles is substantially increased.

The material incorporating such a silicate binder is employed for the manufacture of heaters, resistors, and electrostatic plaster shields.

According to the present invention, it is advantageous to use, as dispersed carbon, graphite carbon with a processing temperature of up to 1,700°C and particle size not greater than 3 μ.

The use of graphite carbon with a processing temperature of up to 1,700°C and at least 1,200°C, makes it possible, in addition to variation of electrical conductivity and thermophysical characteristics of dispersed carbon material *per se*, to enhance its resistance against chemical attach and heat-resistance.

The use of graphite carbon having various particle sizes less than 3 μ makes it possible to improve uniformity of the articles in respect to electrical conductivity.

As a dielectric filler for the electroconductive material of the present invention use may be made of such dielectric substances as quartz sand, corundum, and periclase; in case the silicate binder is sodium liquid glass, the filler may be pelletised blast-furnace slag.

For better understanding of the present invention, some specific examples illustrating compositions of the material according to the present invention (all quantities are expressed as % by volume) intended for the manufacture of articles therefrom are given hereinbelow.

The resistor is a component of an electric circuit, having active electrical resistance. Electrical resistance is the main parameter of a resistor. Resistance of spatial resistors depends on the resistivity value of the material they are being made from.

The principal method of controlling the value of resistivity of an electroconductive material resides in changing its composition. Increased volumetric concentration of dispersed carbon ensuring electrical conductivity

of the composition material results in its decreased resistivity. A silicate binder which is present in the composition acts not only as a binder consolidating its components, but as a reagent through a liquid phase whereof a physicochemical interaction of the components is effected. These physico-chemical processes occur during hardening of the material and their intensity may be controlled by varying the hardening conditions. The material strength is mainly determined by the volumetric concentration of silicate binder and dielectric filler, since the latter forms a rigid framework and facilitates a more uniform distribution of dispersed conductor within the bulk of the material.

Moreover, both the silicate binder and dielectric filler due to their thermal conductivity and heat capacity, take an active part in dissipation of electric energy within the bulk of the material, whereby this energy is converted by the resistor into heat.

To determine the properties of electroconductive materials prepared from the above-mentioned components, test specimens have been made therefrom using various compositions of the material; the specimens were of a cylindrical shape and had a diameter of 5, 10, and 15 cm. and a height of 5 and 10 cm. for each diameter.

These specimens were used for electroconductivity measurements in weak and strong fields. The weak-field measurements were performed using an ohmmeter, while the strong-field measurements were made using a pulse voltage with a wave of 15/40, 10/20, 100/200, and 3,000/8,000 μ sec. and alternating voltage of industrial frequency connected to a high-voltage source for a period of from 0.04 to 2 sec.

These measurements made it possible to determine the non-linearity of the material current-voltage characteristics described by the non-linearity factor α from the equation $U = AI^{\alpha}$; the permissible value of energy dissipated within the material at a single and repeated switching, as well as the permissible value of mean field strength for a cylindrical specimen.

The same test specimens were used for measuring the thermal resistance coefficient of the material. Mechanical strength tests were performed with specimens of a cubic shape having 10 and 7 cm edge. The results of the above-mentioned tests are given hereinbelow in Tables 1, 2, and 3.

Examples of compositions of the electroconductive material useful for the manufacture of volume resistors comprising dispersed carbon, a silicate binder, *viz.* cement, and a dielectric filler are given in the following Table 1, the amounts being expressed in percent by volume. It may be seen from Table 1 that, all other things being equal, the resistivity of an electroconductive composition and the permissible value of specific energy dissipated therein as well as the thermal resistance coefficient and the non-linearity of current-voltage, characteristics depend on the volumetric proportions of the composition ingredients and primarily on the volumetric concentration of dispersed carbon.

TABLE 1

Composition of the starting materials				Test Results					
Portland cement (compression strength of at least 400 kg/cm² vol. %	Finely divided carbon with particle size of not greater than 3 μ vol. %	Dielectric filler with 0.3 mm particle size, vol. %	Water, vol., %	Resistivity, ρ ohm. cm.	Compression strength δ kg/cm²	Specific energy dissipated under short term "on" conditions, J/cm³	Thermal resistance coefficient, 1/°C	Non-linearity factor α from the equation: $U = AI^{\alpha}$	Permissible field strength along the surface at alternating voltage applied for 0.04 s., V/cm.
1.28.8	8.8	43.6	18.8	10^5–10^4	300	60	30.10^{-4}	0.5	1.000
2.27	16.4	39	17.6	450–550	230	160	7–10.10^{-4}	0.84	600
3.10.2	23.7	48.6	17.5	1–3	50	280	5–7.10^{-4}	0.96	350

With the volumetric concentration of dispersed carbon being 8.8% by volume, the resistivity of the composition is from 10^4 to 10^5 ohm.cm. When the volumetric concentration is increased, the resistivity value decreases according to the non-linear law: at 16.4% by volume it drops to 450—55 ohm.cm. and at 23.7% by volume it becomes as low as 1—3 ohm.cm. At the same time, the permissible value of energy dissipated within an article under short-term "on" conditions is increased, reaching as high as 280J/cm³, the volumetric concentration of finely divided carbon being 23.7% by volume.

The thermal resistance coefficient and non-linearity of current-voltage characteristics will decrease with increasing volumetric concentration of dispersed carbon and density of the prepared material.

The permissible intensity of electric field (mean value) increases as the electroconductive material resistivity is increased.

The permissible heating temperature for articles made of a composition containing, as a silicate binder, an aqueous cement solution does not exceed 150°C.

Examples of compositions of the material incorporating, as a silicate binder, a mixture of sodium liquid glass and sodium fluorosilicate, as well as test results for the compositions are given in the following Table 2.

Resistivity of a composition containing

sodium liquid glass, as seen from table 2, shows a more pronounced dependence on the volumetric concentration of dispersed carbon as compared with cement binder due to the colloidal state of the silicate binder.

Increased heat-resistance of a solid residue of the silicate binder, *viz.* liquid glass, ensures increased values of permissible heating temperature, i.e. up to 400°C of the prepared material.

The thermal resistance coefficient of an electroconductive composition depends on both the volumetric concentration of dispersed carbon and the ratio between linear expansion coefficients of each of the composition components. It decreases with increasing volumetric concentration of dispersed carbon and with the decreasing difference between the linear expansion coefficients of the components.

TABLE 2

	Composition of the starting materials				Test Results				
	Sodium liquid glass with a 1.32 g/cm³ specific gravity vol. %	Carbon with particle size of 3 μ, not greater vol. %	Sodium fluosilicate vol. %	Dielectric filler vol. %	Resistivity ρ ohm.. cm.	Compression strength, δ kg/cm²	Specific energy dissipated under short-term "on" conditions j/cm	Thermal resistance coefficient, 1/°C	Non-linearity factor α from equation U = A.I
1.	25	6.75	2.05	66.2	10^5	300	70	40.10^{-4}	0.5
2.	22.5	20	1.8	55.7	5	100	280	10.10^{-4}	0.9
3.	20.	75	2.0	3.0	0.1	50	500	3.10^{-4}	1.95

The non-linearity of current-voltage characteristics of an electroconductive composition also depends on the volumetric concentration of dispersed carbon and the degree to which its particles are packed.

Examples of compositions of the electroconductive material incorporating, cement and sodium liquid glass as a silicate binder (in amounts of up to 30% by volume based on the total volume of the binder) and results

of tests performed therewith are given in Table 3 hereinbelow.

A distinctive feature of this binder resides in a combination of a silicate binder which to a certain extent acts as a filler and a colloidal silicate binder, i.e. cement.

Among the advantages of this binder are increased heat-resistance of the prepared material which is due to the use of another component, *viz.* liquid glass, and the simple technology of the material preparation inherent in cement.

As seen from Table 3, the resistivity value of a composition depends on volumetric proportions of the composition components and, primarily, on the volumetric concentration of dispersed carbon. The resistivity varies from 4.10^4 ohm.cm. with the volumetric concentration of dispersed carbon being 6.75% by volume, to 0.8 ohm.cm. at 57% by volume concentration of dispersed carbon. The resistivity versus volumetric concentration of dispersed carbon curve is also of a non-linear character. With increasing volumetric concentration of dispersed carbon, the value of permissible specific energy dissipation with the material under short-term "on" conditions is increased, while the temperature resistance coefficient and the non-linearity of current-voltage characteristics of the electroconductive material are decreased along with decreased mechanical strength thereof.

TABLE 3

Composition of starting materials					Test Results				
Slag-Portland cement, ultimate compression strength at least 400 kg/cm² vol. %	Sodium liquid glass with specific gravity of 1.32 g/cm³, vol. %	Dielectric filler with particle size of 3 mm vol. %	Carbon with particle size of less than 3 μ	Water, vol., %	Resistivity, ρ ohm. cm.	Compression strength δ, kg/cm²	Specific energy dissipated under short-term "on" conditions J/cm³	Thermal resistance coefficient, 1/°C	Non-linearity α factor from equation $U=AI^{\alpha}$
27.9	10.4	44.55	6.75	10.4	4.10^4	350	70	40.10^{-4}	0.55
20.2	8.6	41.5	17.4	12.3	300–350	150	250	12.10^{-4}	0.8
17.5	7.5	10.0	57.0	8.0	0.8	80	400	$3.3.10^{-4}$	0.95

The heat-resistance of articles made from compositions based on a silicate binder comprising cement and liquid glass is about 250°C.

Earthing connections are obligatory components of electrotechnical networks houses, and buildings. They enable effective operation of these networks and are intended for ensuring safety of the operating personnel.

The material of the present invention is employed, as a rule, for the manufacture of spatial earthing connections with metal reinforcement elements used in supporting structures being retained provided they are simultaneously serve as foundations. The reinforcement serves in this case as a current lead-in.

Earthing connections may be manufactured of any shape and dimensions.

One of the decisive parameters of the material used for the manufacture of earthing connections bearing mechanical load such as the foundation of an electrochemical structure is its mechanical strength. From the viewpoint of ensuring the necessary value of this strength of at least 200 kg/cm², the volumetric concentration of cement binder and dielectric filler in the composition should be increased. To increase the mechanical strength, it is advisable to replace a portion of the powdered dielectric filler by rubble. Any further increase of volumetric concentration of dispersed carbon over 19% by volume (this concentration ensures the required resistivity value), is inexpedient, since the mechanical strength of the article material would be insufficient.

The resistivity value of the electroconductive composition should be several times smaller than the resistivity of the soil where the ground connection is installed and should vary from 80 to 200 ohm.cm.

Tests of the material compositions employed for the manufacture of spatial ground connections were performed with specimens of a prismatic shape with dimensions 4 x 4 x 16 cm. During the manufacture, steel reinforcement simulating a lead-in was placed along the specimen axis. The tests were performed under artificial ground conditions with different resistivity values.

The mechanical properties of the articles were determined using cube-shaped specimens with a 10 cm. edge.

Examples of the material compositions employed for the manufacture of earthing connections and the test results are given in the following Table 4.

For the reinforcement purposes a portion of the dielectric filler is replaced by rubble.

As seen from Table 4, the resistivity of electroconductive compositions depends on volumetric proportions of the components. A decisive factor in this respect is the volumetric concentration of dispersed carbon. When the latter is decreased, the composition resistivity increases. At the same time, a decrease in the volumetric concentration of dispersed carbon at the expense of increased concentration of the binder and dielectric filler improves the mechanical strength of the electroconductive composition material, i.e. its tensile and compression strengths.

The physico-chemical processes taking place between the composition components during hardening contribute to an increase in its resistivity.

TABLE 4

	Composition of the starting materials					Test Results		
	Portland cement, ultimate compression strength at least 400 kg/cm², vol. %	Carbon with particle size of less than 3 μ, vol. %	Dielectric filler – quartz sand, vol. %	Rubble with particle size of less than 10 mm, vol. %	Water, vol., %	Resistivity, ρ, ohm. cm.	Compression strength, δc kg/cm²	Tensile strength, δt kg/cm²
1.	7.4	18.3	11.3	45	18	80–90	160–180	25
2.	8.1	17.4	11.3	45	18.2	90–120	200	30
3.	8.6	16.5	12.7	44	18.2	180–200	230	33

The use of an aqueous cement solution as a binder in the production of the electroconductive material employed for the manufacture of spatial earthing connections ensures their long service life and reliability of operation in soil. The electronic nature of the composition conductivity due to the electrical conductivity of its component, namely dispersed carbon, ensures corrosion resistance of metal reinforcement used in earthing connections.

Electroconductive floors made of the material according to the present invention are used to remove static electricity.

They are made either in the form of a mosaic cast floor or from commercially fabricated tiles. In both cases, metal reinforcement is placed therein. To ensure an attractive appearance, marble crumb or other materials may be introduced into the floor compositions.

Electrical and mechanical properties of compositions of the electroconductive material employed for the manufacture of electroconductive floors were tested on cube-shaped specimens with 7 and 10 cm edges and on prism-shaped specimens with dimensions 4 × 4 × 16 cm. as well as on model specimens in the form of 100 × 50 × 5 cm. plates.

Examples of compositions of the material employed for the manufacture of electroconductive floors according to the present invention and results of their tests are given in the following table 5.

TABLE 5

	Composition of the starting materials					Test Results		
	Portland cement, ultimate compression strength of at least 400 kg/cm², vol. %	Carbon with particle size of less than 3 μ vol. %	Dielectric filler with particle size 3 mm., vol. %	Marble rubble with particle size of less than 10 mm., vol. %	Water, vol. %	Resistivity ρ, ohm. cm.	Compression strength δ_c, kg/cm²	Tensile strength, δ_t, kg/cm²
1.	13.6	18.0	43.4	–	25.0	2.300	230	150
2.	12.7	19.8	11.0	30.5	26.0	1.600	200	140
3.	9.8	21.0	43.6	–	25.6	1.350	180	130

The value of creepage resistance is proportional to the resistivity value of the material employed for the manufacture of electroconductive floors. Compositions shown in Table 5 ensure a creepage resistance not exceeding 50,000 ohm.

The metal reinforcement of such floors under operating conditions should be permanently grounded to the common grounding circuit of the house or building for the purpose of stabilizing the creepage resistance.

One of the requirements imposed on the material employed for the manufacture of electroconductive floors resides, in addition to a specified electrical conductivity, in the mechanical strength which should be sufficient in each particular case. For this reason, the volumetric concentration of dispersed carbon which is a decisive factor for these parameters of the material must be such as to satisfy said reuirements. Increased concentration of the cement binder and dielectric filler as well as substitution of a portion of the latter for marble crumb or other decorative materials, results in increased mechanical strength of the composition. To produce floors having creepage resistance not exceeding 50,000 ohm. and sufficient mechanical strength, there should be employed an electroconductive material with a resistivity ranging from 1,200 to 2,500 ohm.cm. which is achieved by introducing into the composition dispersed carbon of size 1—3 μ in amounts of 18—20% by volume. In addition, to increase the mechanical strength

of the material, use should be made of dispersed carbon with the particle size of at least 1 μ.

As seen from Table 5, the presence of dispersed carbon in the material improves to a certain extent its impact strength as compared to that of conventional types of structural concrete.

Electric heaters from the material of the present invention are made, as a rule, multilayered. A layer of the electroconductive material is placed between the layers of other materials. The outside layers of a heater are made of a heat-resistant electro-insulating material and intended for providing electrical safety of the heater. They are manufactured by applying an insulating layer onto the article surface, followed by a corresponding treatment such as drying or calcination. The layers directly adjacent the electroconductive layer, *viz.* the heater *per se*, may serve various purposes, namely; act as a supporting layer bearing all mechanical loads or as a layer accumulating heat energy due to its intrinsic heat capacity and giving up its heat to the environment in case the heater is disconnected from the electric circuit.

The thermophysical properties of the materials to be employed are of prime importance in the manufacture of these electric heaters.

The technology of making electric heaters from the material of the present invention contemplates inserting metal electrodes into the electroconductive layer during its fabrication. These electrodes may act at the same time as transverse reinforcing members of the article.

The electric, thermophysical, and physico-mechanical properties of the compositions employed for the manufacture of electric heaters were tested on specimens of a cubic shape with an edge of 7 and 10 cm., on prismatic specimens having dimensions 4×4×16 cm., and cylindrical specimens with a 5 cm. diameter and 5 cm. height. In addition, tests were performed with heater models having different configurations and dimensions in accordance with the intended purpose thereof. Examples of compositions of the material used for the manufacture of heaters and the test results are given in Table 6 hereinbelow. (See page 23).

As seen from Table 6, heating elements are made of compositions which may include as a silicate binder such components as liquid glass, cement, and a mixture of cement with liquid glass.

The resistivity of the electroconductive materials, as in the above Examples, depends on the volumetric proportions of the components and, primarily, on the concentration of dispersed carbon.

The heat-resistance of the electroconductive materials is determined by the properties of the employed silicate binders in the hardened condition: it is 150°C for cement; 300—400°C for liquid glass; 250°C for a mixture of cement and liquid glass. Moreover, the heat-resistance of an electroconductive material is strongly influenced by heat-resistance and thermophysical characteristics of dispersed carbon.

Heat capacity of the electroconductive material is defined by the total heat capacity of their components.

The data shown in Table 6 were obtained with quartz sand employed as a dielectric filler.

When the same materials are employed as the starting components, the composition heat capacity varies but insignificantly even with the use of different types of a silicate binder (cf. Table 6).

Electrostatic shields from the material of the present invention for electromagnetic waves of sound frequencies are made in the form of a plaster applied onto wall surfaces over a metal reinforcing netting with 10—20 cm. cells by conventional methods as used in construction work. The shielding effect of the plaster shields depends on the particle size of finely-divided carbon incorporated therein. In this particular case, the volumetric concentration of dispersed carbon should be much greater than in the previous cases. Powdered carbon with 0.15 to 0.5 mm particle size may be used in the composition instead of the dielectric filler or a portion thereof in some cases.

TABLE 6

	Composition of the starting materials					Test Results					
	Portland cement or slag-portland cement ultimate compression strength at least 400 kg/cm^2 vol. %	Sodium liquid glass with specific gravity of 1.32 g/cm^3, vol. %	Carbon with particle size of less than 3 μ vol. %	Dielectric filler with particle size of 0.3 mm., vol. %	Water, vol. %	Resistivity, ρ, ohm. cm.	Compression strength, δ, kg/cm^2	Heat resistance, °C	Heat giving-up capacity at vertical position indoors W/cm^2 °C	Thermal resistance coefficient, 1/°C	Heat capacity, j/cm^3 °C
1.	27	–	16.4	39	17.6	450–550	200	150	$1.48.10^{-4}$	10.10^{-4}	$11.2.10^{-2}$
2.	18.6	9.0	17.8	42	12.6	300	150	250	$1.48.10^{-3}$	9.10^{-4}	12.10^{-2}
3.	–	30	20	50	–	20	150	300	$1.48.10^{-3}$	6.10^{-4}	$12.3.10^{-2}$

The electric properties of the material according to the present invention were tested on specimens of a cylindrical shape having 5 cm. diameter and 5 cm. height. Physio-mechanical properties, such as compression strength were determined on cube-shaped specimens with an edge of 7 and 10 cm. as well as on prism-shaped specimens with dimensions 4 x 4 x 16 cm. Shielding effect of the plasters according to the present invention was determined using two-layer 100 x 100 cm plates. One of the layers is self-supporting and is made of conventional concrete with a thickness of 5—7 cm., while the second layer is a shield; it is made of the material of the present invention which material is applied onto a metal reinforcing net with 10—20 cm. cells so as to form a 3—5 cm. thick layer. A closed structure with sealed corner joints was assembled from said plates to be employed for determining the shielding effect of the material of the present invention. Examples of compositions of the material employed for the manufacture of shielding plasters according to the present invention and the test results are shown in the following Table 7.

As seen from Table 7, the resistivity value

of the electroconductive material does not exceed 10 ohm.cm. The range of shielded frequencies is widened with increasing volumetric concentrations and fineness of carbon, but its upper limit does not exceed 50 kc./s. for the compositions shown in the Table.

Since no special requirements are imposed on the mechanical strength of the materials employed as wall-plasters, obtaining the mechanical strength of 20—30 kg/cm² may be considered as being sufficient.

The shielding plasters may be painted with lime-based or synthetic painting materials to impart the required appearance and colour thereto.

TABLE 7

Composition of the starting materials					Test Results		
Portland cement, vol. %	Sodium liquid glass of 1.32 g/cm³ specific gravity, vol. %	Dispersed carbon with particle size of less than 3 μ, vol. %	Dielectric filler, vol. %	Water, vol., %	Resistivity, ohm. cm. ρ	Compression strength δ, kg/cm²	Range of shielded frequencies kc/s
1. 13.1	3.3	32.6	16.2	34.8	5	30	20
2. 16	—	32	17	35	10	30	22
3. 8.9	—	44.4	8.7	38	2–3	20	50

WHAT WE CLAIM IS:—

1. An electroconductive material with a predetermined resistivity value comprising a composition of a dielectric filler and a silicate binder with dispersed carbon having particles of various sizes not exceeding 3 μ, uniformly distributed among the particles of said dielectric filler and silicate binder, said components being taken in the following proportions: dispersed carbon from 6.75 to 85% by volume, dielectric filler from 1 to 60% by volume, and silicate binder from 7 to 85% by volume.

2. An electroconductive material according to Claim 1, wherein the silicate binder is cement.

3. An electroconductive material according

to Claim 1, wherein the silicate binder is a mixture of sodium liquid glass with specific gravity of 1.32 g/cm^3 and sodium fluorosilicate, the mixture being taken in amounts ranging from 9 to 40% by volume.

4. An electroconductive material according to Claim 1, wherein the silicate binder is a mixture of cement and sodium liquid glass, the latter being employed in amounts of up to 30% of the total volume of the binder.

5. An electroconductive material according to Claim 1, wherein dispersed carbon is graphite carbon.

6. A resistor made of the material according to Claims 2, 3, 4 set forth hereinbefore.

7. An earthing connection made of the material according to Claim 2 set forth hereinbefore.

8. An electroconductive floor made of the material according to the foregoing Claim 2 and intended for removing static electricity.

9. An electric heater made of the material according to the foregoing Claims 2, 3, or 4.

10. An electrostatic shield-plaster for premises made of the material according to the foregoing Claims 2, 3, or 4.

11. A electroconductive material according to Claim 1, substantially as hereinbefore described.

FITZPATRICKS,
Chartered Patent Agents,
14—18 Cadogan Street, Glasgow G2 6QW
— and —
Warwick House, Warwick Court,
London WC1R 5DJ.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1976.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.